## Space Weather Technical Forecast

Issued on Sunday 5 January 2025 at 13:29 Local

**This technical forecast provides a four-day assessment of space weather events. The probabilities stated below are for reaching or exceeding the given levels. For more information about space weather impacts please see the Met Office Space Weather Scales https://www.metoffice.gov.uk/weather/learn-about/space-weather/uk-scales**

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**Space Weather Forecast Headline: M-class flares expected, with an increased chance of X-class flares. Chance of further G1 Minor Geomagnetic Storms Day 1 (05 Jan).**

**Analysis of Space Weather Activity over past 24 hours**

**Solar Activity:** Solar activity has been High with an X1.8 flare at 04/1248UTC and several M-flares, all from AR3947 in the northeast of the solar disc.

There are currently eleven sunspot regions visible on the Earth-facing solar disc. Despite the high number of spots, most are small and magnetically simple. AR3947 in the northeast is the largest and most complex spot and has been responsible for the bulk of recent activity, with three lower X-class flares now recorded since appearing over the eastern limb. It features several moderately sized spots, including a delta region among its trailing spots. AR3943, now near the central disc, and AR3945, trailing behind it, exhibit some magnetic complexity but have remained relatively stable in recent hours. AR3939, despite being magnetically simple, produced two large CMEs (coronal mass ejections) on the 04 Jan, in association with two C-class flares. However has shown signs of decay in recent hours. Otherwise there has been little significant changes to the remaining regions on the Earth facing-disc.

Two CMEs occurred from AR3939 in association with C-flares at 04/1444 and 04/1827. It is likely both of these CMEs will pass ahead of Earths orbit, however there is a slight chance that the latter CME may deliver a glancing blow late on Day 2 (06 Jan) or early on Day 3 (07 Jan).

**Solar Wind / Geomagnetic Activity:** Solar wind speeds observed by ACE at L1 increased during the first half of the period due to a connection with the high-speed stream from CH05/+. Speeds initially measured around 500 km/s, peaking at a strong 700 km/s at 04/2330 UTC. Since then, solar winds have been gradually declining, reaching the current elevated levels of approximately 550 km/s. Density was below average levels. The Interplanetary Magnetic Field, Bt, started strong at around 17nT, before easing back to current weak levels of 7nT. The north-south component, Bz, fluctuated between negative and positive through much of the period, initially ranging between +12nT and -12nT, but then oscillated weakly from around 04/1800UTC. The Phi angle was mostly positive (Away the Sun).

Geomagnetic activity was mainly unsettled to active (Kp3-4) , but with G1/Minor geomagnetic storm (Kp5) conditions recorded between 04/1800-2100 UTC.

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**Energetic Particles / Solar Radiation:** High energy proton flux (greater than 10MeV) at GOES18 breached the S1 Minor Storm threshold at 04/2215UTC in response to a C-flare from AR3939 at 04/1827 UTC, peaking at 2.0pfu at 05/0555 UTC and declining below the S1 threshold at 05/0950 UTC.

High energy electron flux (greater than 2MeV) at GOES16 was at background to moderate levels with the associated 24 hr fluence well below Active. The 05/0000 UTC fluence observation was 3.02e6 integrated pfu.

**Four-Day Space Weather Forecast Summary**

**Solar Activity:** Activity is forecast to be Moderate to High, with further M-class flares expected and a chance of further isolated X-flares, mainly from AR3947.

**Solar Wind / Geomagnetic Activity:** There is a slight chance of a glancing blow from a CME later on Day 2 (06 Jan) or early on Day 3 (07 Jan), but it is more likely the CME will pass ahead of Earths orbit. Earths connection to a HSS associated with CH05/+ is expected to wane over the next few days. Elevated to Strong solar winds of 550-650km/s are likely on Day 1 (05 Jan), declining slowly into Days 2 and 3 (06-07 Jan), perhaps back to background levels by Day 4 (08 Jan).

Geomagnetic conditions are expected to be mainly quiet to unsettled (Kp1-3) through the period, with a slight chance of a few active or G1 Minor geomagnetic storm intervals (Kp4-5) initially in association with the HSS and also later Day 2 (06 Jan) or early Day 3 (07 Jan) if a glancing blow occurs from the aforementioned CME.

**Energetic Particles / Solar Radiation:** GOES18 high energy proton flux has now decreased back below the S1 threshold after recent enhancement. There is a slight chance of further enhancement over the next few days should any further significant flares occur from the west of the disc.

GOES16 high energy electron flux is expected to continue at background initially due to current HSS influences. However, electron flux may rise to moderate or high levels later in the period as the influence of the HSS begins to wane. The associated fluence is expected to remain below the Active threshold, however there is a slight chance of exceeding the active threshold later in the period due to the risk of rising flux levels.

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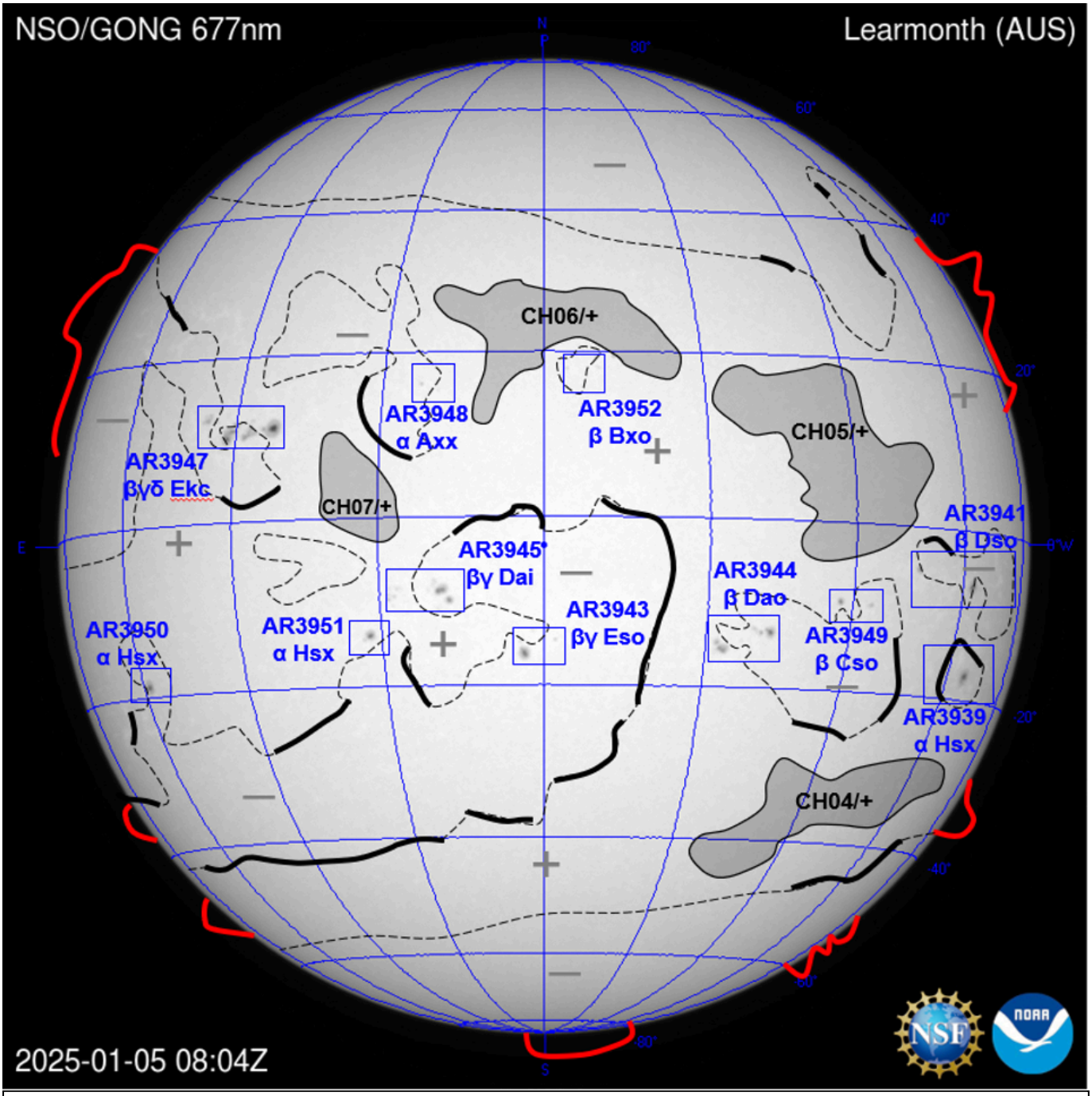
**Figure 1: Solar Synoptic Map 05/0800 UTC**




**Key:** Filament ___ , Prominence ___ , Magnetic Field Line - - - , Polarity +/-, Coronal Holes: Grey shaded area CHxx +/-, Sunspot groups 25xx - Mt Wilson α-β-βγ-βγδ and Zurich-McIntosh Axx etc.

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## Geomagnetic Storms

Two CMEs occurred from AR3939 in association with C-flares at 04/1444 and 04/1827. It is likely both of these CMEs will pass ahead of Earths orbit, however there is a slight chance that the latter CME may deliver a glancing blow late on Day 2 (06 Jan) or early on Day 3 (07 Jan).

Earth has been connected to a HSS associated with CH05/+ in the northwest of the solar disc since 04/1400UTC. This coronal hole was originally a larger hole consisting of CH05/+ and CH06/+ which has since been split. Both coronal holes are persistent, although were smaller and further to the solar east on last rotation. Solar winds have been declining slowly over the past 12 hours and are expected to continue this decline over the coming days. Elevated to Strong solar winds of 550-650km/s are likely on Day 1 (05 Jan), declining slowly into Days 2 and 3 (06-07 Jan), perhaps back to background levels by Day 4 (08 Jan). It should be noted however that the density in the HSS is low and hence the resulting geomagnetic conditions are not expected to be significantly enhanced. MOSWOC ENLIL has the connection to the HSS too late, but its slow decline suggested following connection is accepted.

Geomagnetic conditions are expected to be mainly quiet to unsettled (Kp1-3) through the period, with a slight chance of a few active or G1 Minor geomagnetic storm intervals (Kp4-5) initially in association with the HSS and also later Day 2 (06 Jan) or early Day 3 (07 Jan) if a glancing blow occurs from the aforementioned CME.

| Geomagnetic Storm | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability (Exceedance) | | | (%) | (%) | (%) | (%) |
| Minor or Moderate | G1 to G2 | Yes | 20 | 15 | 10 | 1 |
| Strong | G3 | No | 1 | 1 | 1 | 1 |
| Severe | G4 | No | 1 | 1 | 1 | 1 |
| Extreme | G5 | No | 1 | 1 | 1 | 1 |

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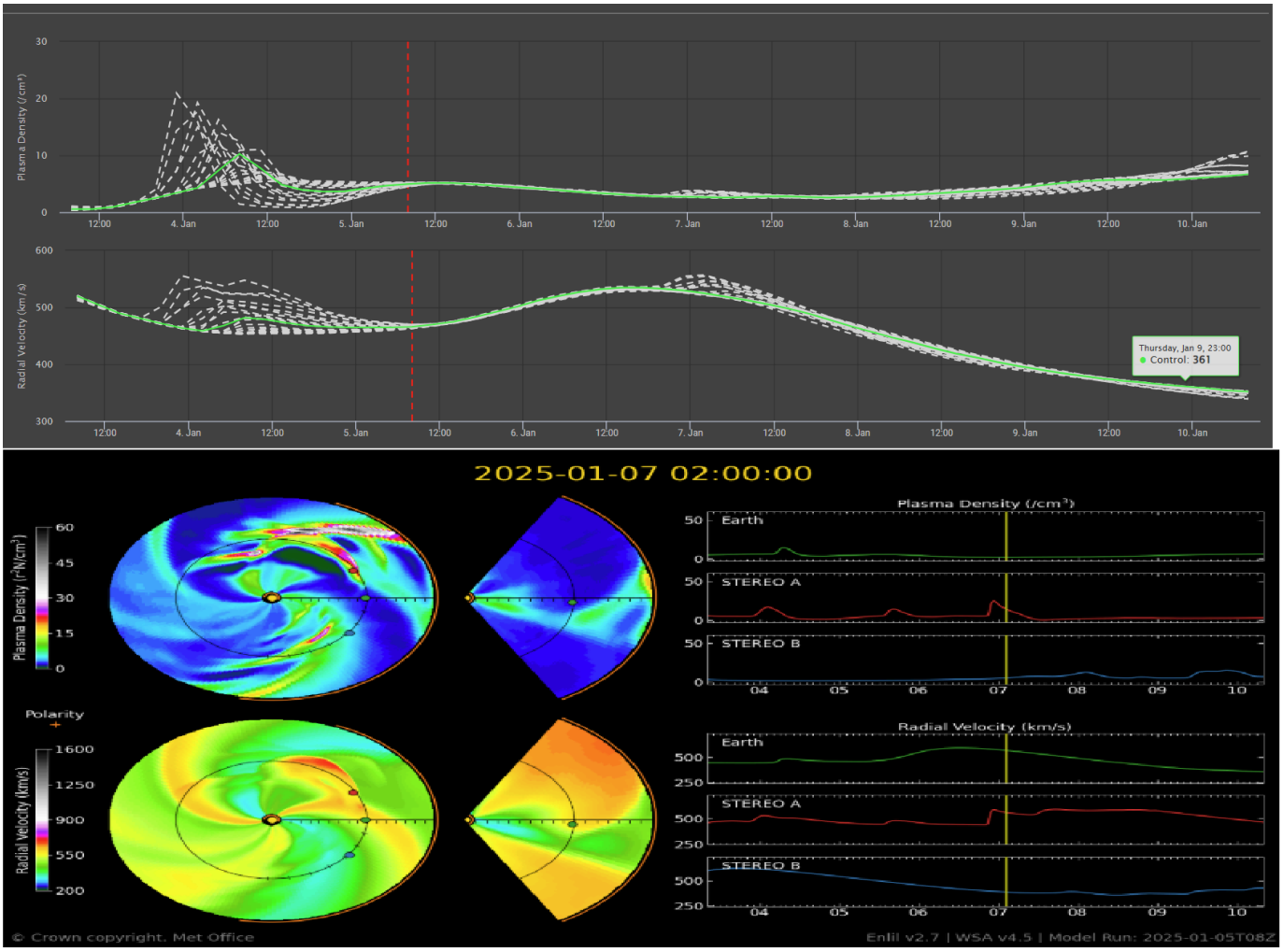
**Figure 2: MOSWOC ENLIL**



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## Radio Blackouts - X-Ray Flares

Solar activity has been High with an X1.8 flare at 04/1248UTC and several M-flares, all from AR3947 in the northeast of the solar disc.

There are currently eleven sunspot regions visible on the Earth-facing solar disc. Despite the high number of spots, most are small and magnetically simple. AR3947 in the northeast is the largest and most complex spot and has been responsible for the bulk of recent activity, with three lower X-class flares now recorded since appearing over the eastern limb. It features several moderately sized spots, including a delta region among its trailing spots. AR3943, now near the central disc, and AR3945, trailing behind it, exhibit some magnetic complexity but have remained relatively stable in recent hours. AR3939, despite being magnetically simple, produced two large CMEs (coronal mass ejections) on the 04 Jan, in association with two C-class flares. However has shown signs of decay in recent hours. Otherwise there has been little significant changes to the remaining regions on the Earth facing-disc.

Given that AR3947 has been the most active region and will remain on the solar disc for the next four days, the flare risk is being maintained at a steady level throughout this period, pending any further developments.

Overall, activity is forecast to be Moderate to High, with further M-class flares expected and a chance of further isolated X-flares, mainly from AR3947.

| X-Ray Flares | Level | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability | | | (%) | (%) | (%) | (%) |
| Active | R1-R2 (M Class) | Yes | 80 | 80 | 80 | 80 |
| Very Active | R3-R5 (X Class) | Yes | 25 | 25 | 25 | 25 |

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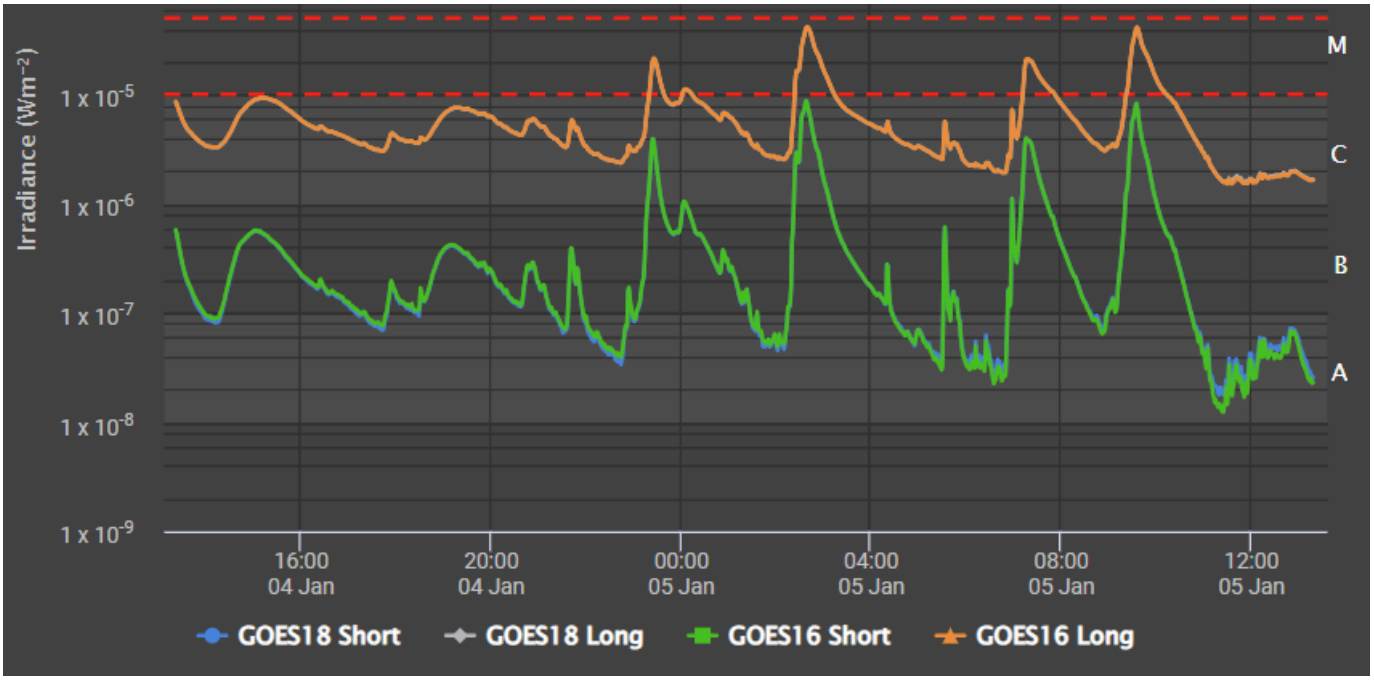
**Figure 3: GOES16/18 X-Ray flux**



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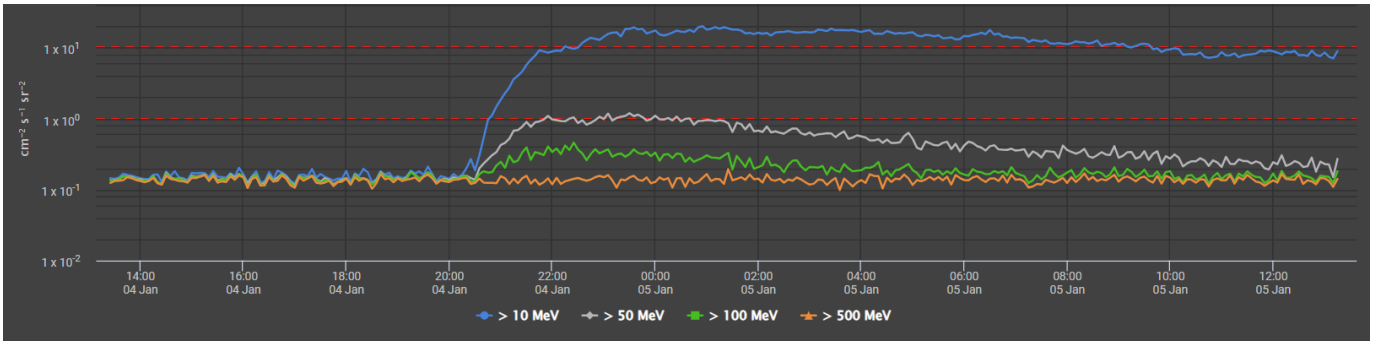
## Solar Radiation Storms (High Energy Protons)

GOES18 high energy proton flux has now decreased back below the S1 threshold after recent enhancement. This enhancement came in association with a C9.1 flare from AR3939 in the southwest of the disc. There is a slight chance of further enhancement over the next few days should any further significant flares occur, mainly from AR3939 but also perhaps initially from regions which have now rotated over the western limb.

| Radiation Storms Probability (Exceedance) | Level ($cm^{-2}sr^{-1}s^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) (%) | Day 2 (00-24 UTC) (%) | Day 3 (00-24 UTC) (%) | Day 4 (00-24 UTC) (%) |
|---|---|---|---|---|---|---|
| **Active** | **≥ S1** | Yes | 20 | 20 | 15 | 15 |
| **Very Active** | **≥ S3 *** | No | 1 | 1 | 1 | 1 |
| * S3 ≥ 10 MeV ≥ 1000 pfu and/or 50 MeV ≥ 10pfu. (pfu = $cm^{-2}sr^{-1}s^{-1}$) | | | | | | |

**Figure 4: GOES18 Proton Flux**

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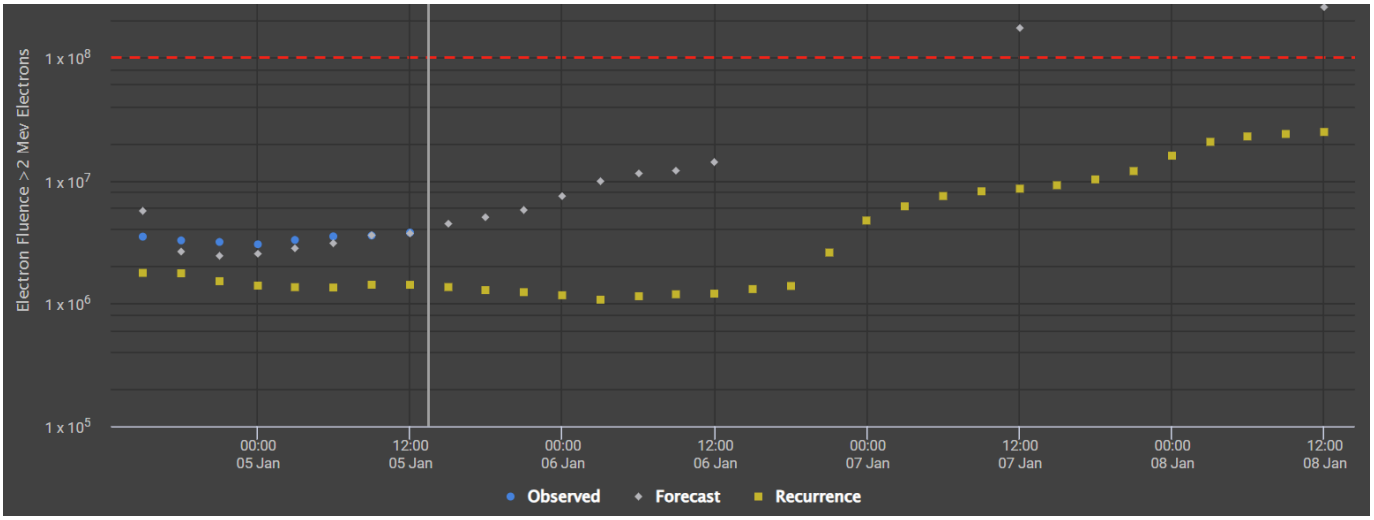
## High Energy Electrons (≥ 2MeV)

High energy electron flux observed at GOES16 is currently at background levels following the connection to the high speed stream from CH05+. This HSS has resulted in strong solar winds, which are expected to continue suppressing the radiation belt away from geostationary orbit (GEO). As a result, electron flux is anticipated to remain at background levels through Day 1 and Day 2 (06–07 Jan). However, electron flux may rise to moderate or high levels later in the period as the influence of the HSS begins to wane

The associated 24-hour fluence is expected to remain below active levels overall. However, due to the potential for rising electron flux levels later in the period, there is a slight chance that fluence could exceed the active threshold, as suggested by MOSWOC ENLIL.

| GEO Electron Environment | Level ($cm^{-2}sr^{-1}$ $day^{-1}$) | Past 24 Hours (Yes/No) | Day 1 (00-24 UTC) | Day 2 (00-24 UTC) | Day 3 (00-24 UTC) | Day 4 (00-24 UTC) |
|---|---|---|---|---|---|---|
| Probability (Exceedance) | | | (%) | (%) | (%) | (%) |
| Active | ≥ 2 MeV ≥ $1\times10^{8}$ | No | 1 | 1 | 10 | 20 |
| Very Active | ≥ 2 MeV ≥ $1\times10^{9}$ | No | 1 | 1 | 1 | 1 |

**Figure 5: MOSWOC REFM showing potential fluence rises later in the period**

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